

the pressure and the irradiation quantity.

Further the insulation film with high mechanical strength and low relative dielectric constant can be obtained by changing a parameter other than the pressure and irradiation quantity. The parameter other than the pressure and irradiation quantity is one of temperature of the semiconductor substrate 1, type of gas having the semiconductor substrate 1 exposed thereto, flow rate of the gas introduced into the reactor chamber, and position of the semiconductor substrate 1. For example, in the step 4, the similar effect can be obtained by changing the temperature from 400°C to 200°C, changing the gas type from nitrogen to argon, changing the flow rate of the gas from 25 slm to 3 slm, or changing the position of the semiconductor substrate 1 from 50 nm to 120 nm.

However, in this case, the insulation film may not be obtained by the degrees of demand of mechanical strength and relative dielectric constant. Therefore, in generally, it is preferable to change a plurality of the parameters. The similar effects can be obtained by changing a plurality of the parameters other than the pressure and irradiation quantity, or one of the pressure and irradiation quantity and at least one of parameter other than the pressure and irradiation quantity.

Namely, the effects as shown in the present

embodiment can be obtained by changing at least one of the pressure in the reactor container, the temperature of the semiconductor substrate 1, the type of gas having the semiconductor substrate 1 exposed thereto, the flow rate of the gas introduced into the reactor container, the position of the semiconductor substrate 1, and the irradiation quantity.

Further, in the step 4, the pressure and the irradiation quantity are changed in the direction of increasing and decreasing respectively, however, even if one of the parameters is changed in an opposite direction, there is a case that the effects of the present embodiment can not be obtained. In generally, the direction (increasing, decreasing) of change of the parameters is important to obtaining a desired effect by changing a plurality of parameters. In generally, the direction differ by the selected parameters, or the degrees of demand of mechanical strength or relative dielectric constant. Therefore the direction of change of the parameters are appropriately selected.

The above described parameters can be specifically changed within the following range. The pressure can be changed in a range from higher than 0 Torr to not more than 40 Torr; the temperature can be changed in a range from not less than 200°C to not more than 500°C; the type of gas can be changed among a nitrogen gas, a rare gas, a reduction gas (for example H_2) and a

5 mixture at least two gases of the nitrogen gas, rare
gas and reduction gas whose oxygen concentration is not
higher than 100 ppm; the flow rate of gas having the
substrate exposed thereto, the gas can be changed in a
range of from higher than 0 slm to not more than
25 slm; the position of the semiconductor substrate 1
can be changed in a range from not less than 50 mm to
not more than 120 mm in distance from a lower end of
the electron beam generating section; and the
10 irradiation quantity can be changed in a range from not
less than $4 \mu\text{C}/\text{cm}^2 \cdot \text{sec}$ to not more than $10 \mu\text{C}/\text{cm}^2 \cdot \text{sec}$.

15 The heat treatment process in the steps 2 and 3
may be carried out in a reactor container that is
different from that in the step 4. Of course, this
process may be carried out in the same reactor
container as that in the step 4.

20 In addition, the process of the present embodiment
is applied to form an interlayer insulation film at the
bottom layer in a multi-layered wiring structure, the
similar process is applicable to form an interlayer
insulation film in each layer.

(Second Embodiment)

25 Now, a method for manufacturing a semiconductor
device according to a second embodiment of the present
invention will be described here.

The present embodiment is different from the first